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# DOE FUNDAMENTALS **MATERIAL SCIENCE**



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## MATERIAL SCIENCE

### ABSTRACT

*Material Science* was developed to assist nuclear facility operating contractors in providing operators, maintenance personnel, and the technical staff with the necessary fundamentals training to ensure a basic understanding of the structure and properties of metals. The textbook includes information on the structure and properties of metals, stress mechanisms in metals, failure modes, and the characteristics of metals that are commonly used in DOE nuclear facilities. This information will provide personnel with a foundation for understanding the properties of facility materials and the way these properties can impose limitations on the operation of equipment and systems.

**Key Words:** Training Material, Metal Imperfections, Metal Defects, Properties of Metals, Thermal Stress, Thermal Shock, Brittle Fracture, Heat-Up, Cool-Down, Characteristics of Metals

# MATERIAL SCIENCE

## FOREWORD

*Material Science* was prepared as an information resource for personnel who are responsible for the operation of the Department's nuclear facilities. An understanding of material science will enable the contractor personnel to understand why a material was selected for certain applications within their facility. Almost all processes that take place in the nuclear facilities involve the use of specialized metals. A basic understanding of material science is necessary for DOE nuclear facility operators, maintenance personnel, and the technical staff to safely operate and maintain the facility and facility support systems. The information is presented to provide a foundation for applying engineering concepts to the job. This knowledge will help personnel more fully understand the impact that their actions may have on the safe and reliable operation of facility components and systems.

*Material Science* consists of five modules. The following is a brief description of the information presented in each module.

### Module 1 - Structure of Metals

Explains the basic structure of metals and how those structures are affected by various processes. The module contains information on the various imperfections and defects that the metal may sustain and how they affect the metal.

### Module 2 - Properties of Metals

Contains information on the properties considered when selecting material for a nuclear facility. Each of the properties contains a discussion on how the property is affected and the metal's application.

### Module 3 - Thermal Shock

Contains material relating to thermal stress and thermal shock effects on a system. Explains how thermal stress and shock combined with pressure can cause major damage to components.

### Module 4 - Brittle Fracture

Contains material on ductile and brittle fracture - these two fractures are the most common in nuclear facilities. Explains how ductile and brittle fractures are affected by the minimum pressurization and temperature curves. Explains the reason why heatup and cooldown rate limits are used when heating up or cooling down the reactor system.

## *MATERIAL SCIENCE*

### Module 5 - Plant Materials

Contains information on the commonly used materials and the characteristics desired when selecting material for use

The information contained in this textbook is by no means all encompassing. An attempt to present the entire subject of material science would be impractical. However, *Material Science* does present enough information to provide the reader with a fundamental knowledge level sufficient to understand the advanced theoretical concepts presented in other subject areas, and to better understand basic system operation and equipment operations.